Suito Laboratory (Special Issue on the Commemoration of the Fortieth Anniversary)

SUITO LABORATORY (February 1952~)

Head: Dr. Eiji Suito

Suito Laboratory was established to cover the field of "Powder Chemistry" as a part of Physical Chemistry. Under the supervision the staff members of Professor Dr. E. Suito, Assistant Professor Dr. N. Uyeda, Dr. M. Arakawa Dr. K. Takiyama, Mr. M. Shiojiri and Mr. T. Kobayashi have been working mainly on the formation of small crystallites, the morphology and physical property of colloidal particles. The electron microscopy and diffraction are the major procedure for investigation. The 300 kV and 500 kV Ultra High Voltage Electron Microscopes, which have been explored in the collaboration with Professor K. Kobayashi, have been attracted world-wide attention. The abstracts of major research and the published papers are outlined hereunder.

I. Morphology and Crystal Habits of Colloid Particles

The development of electron microscopy enabled the direct observation of the shape of particles dispersed in colloidal system. The shapes of the colloidal particles and powders were observed and the crystal habits of these small crystalline particles were determined by electron microscopy, in relation to their physical properties.

II. Crystal Growth and Phase Transformation in Suspensions

By electron microscopy and X-ray diffractometry, the formation of sol in colloidal system, that of precipitates in analytical chemistry, also that of fine particles of industrial powder products such as pigment, rubber-filler have been investigated in terms of their crystal growth and phase transformation in suspensions as the fundamental process.

III. Structure and Crystal Growth of Vacuum Evaporated Films

Electron microscopy was applied to the studies of the structure of vaccuum deposited thin crystalline films, which have recently been attracting wide scientific interest, in relation to the epitaxy and the process of recrystallization. The crystal transformation, oxidation process and radiation effect were also studied with vacuum deposited thin films.

IV. Particle Size Determination

The particle size of fine powder was measured by the use of various different methods and the effect of the particle size on the physical properties of the powder was also studied. Various methods of particle size determination were studied and new instruments were explored, some of which have been manufactured on the commercial base by the Shimadzu Seisakusho Ltd. and world-widely used in many

laboratories as Sedimentograph, Recording Sedimeter, Autosizer, Permeasizer and Sorptograph for investigation and quality control.

V. Physical Chemistry of Fine Powders

(a) The characteristic properties of fine powders were studied particularly on the effect of the surface state of particles on the physical properties such as packing and flow ability.

(b) The structure of organo-bentonite was investigated by x-ray diffraction, infrared spectroscopy and differential thermal analysis.

VI. Dispersion State of Rubber-Filler System

In order to clarify the reinforcement of rubber, (a) fillers and its dispersed state in rubber were observed by electron microscopy and (b) bonding state between the filler particles and the polymer molecules was investigated by infrared spectroscopy.

VII. Colloid Catalysis

The decomposition of hydrogen peroxide by the gold sol as the contact catalyst was investigated by thermal analysis. The decomposition of hydrogen peroxide by various vacuum deposited metal films was also studied and discussed in terms the relationship between the electron double layer of the surface of catalyst and the catalytic reaction and also that between the lattice defect in the crystalline catalyst and the catalytic action.

VIII. Electron Microscopy

Instrumentation, technique of observation and that of specimen preparation have been continued for electron microscopy.. The 300 kV and 500 kV electron microscopes were explored with the collaboration of Shimadzu Seisakusho Ltd.. The transmissibility of high velocity electrons through crystalline materials was studied by the use of these instruments and the data obtained greatly contributed to the field of electron microscopy.

Publications

(* indicates an article published in Japanese)

I. Morphology and Crystal Habits of Colloidal Particles

1. E. Suito and K. Takiyama: Morphology of Barium Sulfate Precipitate by Electron Microscope., *Proc. Japan Academy,* **28,** 133–138 (1952).
2. E. Suito and N. Uyeda: Absorption Spectra and Electron Microgram of Gold Sol., *Bull. Inst. Chem. Res., Kyoto Univ.,* **30,** 40–41 (1952).
3. E. Suito, N. Uyeda and Y. Sasaki: Studies on Microcrystals by Electron Microscope and Electron Diffraction. (III) On the Colloidal Particles formed by Ultrasonic Stripping Method., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 51–52 (1953).
4. E. Suito and N. Uyeda: Studies of Organic Pigments by Electron Microscope., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 53–54 (1953).

5. E. Suito and N. Uyeda: Electron Microscope and Diffraction Study on Single Micro-Crystals of Colloidal Gold., *J. Electronmicroscopy,* **1,** 33–36 (1953).
6. E. Suito and N. Uyeda: Study of Single Micro-Crystals of Gold by a Three-Stage Electron Microscope., *Proc. Japan Academy,* **29,** 324–330 (1953).
7. E. Suito and N. Uyeda: Study of the Thickness of Single Micro-Crystals of Gold by Electron Diffraction Method., *Proc. Japan Academy,* **29,** 331–336 (1953).
8. E. Suito and N. Uyeda: Thickness Evaluation of the "Trigon" Particles of Gold Sol by the Electron Diffraction Method., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 361–363 (1953).
9. E. Suito, K. Takiyama and N. Uyeda: Colloid Morphological and Crystalline Studies of "Bikini Dust" fallen on the No. 5 Fukuryu Maru by Electron Microscopy and Diffraction Methods., *Bull. Inst. Chem. Res., Kyoto Univ., Supplementary Issue.,* 18–28 (1954); *Kagaku (Tokyo)* **25,** 39–40 (1955); *Research in the Effects and Influences of the Nuclear Bomb Test. Explosions* **1,** 439–448.
10. E. Suito and N. Uyeda: A Study of Flaky Single Micro-Crystals of Gold with a Three-Stage Electron Microscope., *Proc. International Conference of Electron Microscope at London,* 223–231 (1954).
11. E. Suito and N. Uyeda: A Study of the Clay Minerals from Kurata Mine by the Electron Micro-Diffraction Method., *Proc. Japan Acad.,* **32,** 177–181 (1956).
12. E. Suito and K. Takiyama: Electron Microscopic Study on Some Viscous Colloidal Solutions., *Bull. Inst. Chem. Res. Kyoto Univ.,* **34,** 307–315 (1956).
13. E. Suito and N. Uyeda: The Relation between the Crystal Habit and the Lattice Image of Copper-Phthalocyanine., *Proc. Japan Academy,* **33,** 398–402 (1957).
14. E. Suito and N. Uyeda: The Crystal Habit Analysis of Copper Phthalocyanine by the Electron Micro-Diffraction Method., *J. Electronmicroscopy,* **6,** 24–28 (1958).
15. E. Suito and K. Takiyama: Morphology and Crystals Habit of Various Barium Sulfate Precipitates., *J. Electronmicroscopy,* **8,** 87–89 (1959).*

Reviews

16. E. Suito: Electron Microscopic Observation of Various Fine Powders for Industrial Use., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 69–84 (1953).*
17. E. Suito: Shape and Crystal Habit of Colloidal Particles., *Colloid and Surfactant (Japan),* **1,** 209–215 (1960).*
18. E. Suito: Colloid Morphology., *Colloid and Surfactant (Japan),* **2,** 34–36 (1961).*
19. E. Suito: Powder Morphology., *J. Japan Soc. Testing Materials,* **11,** 200–210 (1962).*
20. E. Suito and S. Sakka: Red Color of Gold Sol., *Chemistry (Kyoto),* **17,** 752–755 (1962).*
21. E. Suito: Shapes and Structures of Particles of Fine Powders., *Chemistry (Kyoto),* **19,** 312–321 (1964).*

II. Crystal Growth and Transformation in Solution

(a) Various Carbonates

1. E. Suito, K. Takiyama and M. Takahashi: Formation of Ultrafine Powders. (IV) Formation of Barium Carbonate by Carbonation Method., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 372–374 (1953).
2. E. Suito, K. Takiyama and M. Takahashi: Electron Microscopic Studies on Alkaline Earth Carbonates. (I) Formation by Carbonic Acid Gas Method. (II) Electron Microscopic and Diffraction Studies on Precipitated Particles., *J. Chem. Soc. Japan,* **78,** 1732–1740 (1966).*

(b) Barium Sulfate Precipitate

3. E. Suito and K. Takiyama: Formation and Aging of Precipitates. (I) Electron Microscopic Studies of the Formation of Barium Sulfate Precipitate., *Bull. Chem. Soc. Japan,* **27,** 121–123 (1954).
4. E. Suito and K. Takiyama: Formation and Aging of Precipitates. (II) Electron Microscopic Studies of the Aging of Barium Sulfate Precipitate., *Bull. Chem. Soc. Japan,* **27,** 123–125 (1954).

5. K. Takiyama and E. Suito: An Electron Microscopic Study on the Suspensoid for the Nephelometry of Sulfate Ion., *Analytical Chem. (Japan)* **3,** 291–293 (1954)*, *Bull. Inst. Chem. Res., Kyoto Univ.,* **32,** 143–148 (1954).
6. E. Suito and K. Takiyama: Formation and Aging of Precipitates. (III) Electron Microscopic Studies on Barium Sulfate Precipitates in Aqueous Alcohol., *Bull. Chem. Soc. Japan,* **28,** 305–307 (1955).
7. E. Suito and K. Takiyama: Barium Sulphate Precipitates using EDTA. An Electron Microscopic Study., *Bull. Inst. Chem. Res., Kyoto Univ.,* **34,** 88–89 (1956).
8. K. Takiyama: Formation and Aging of Precipitates. (IX) Formation of Monodisperse Particles. (2) Barium Sulfate Precipitates by EDTA Method., *Bull. Chem. Soc. Japan,* **31,** 950–953 (1958).
9. K. Takiyama: Formation and Aging of Precipitates. (X) An Electron Micro-Diffraction Study on Crystal Habit of Barium Sulfate Precipitates., *Bull. Chem. Soc. Japan,* **32,** 68–70 (1959).
10. K. Takiyama: Formation and Aging of Precipitates. (XI) An Electron Micro-Diffraction Study on Nucleation of Barium Sulfate Precipitate from Homogeneous Solution., *Bull. Chem. Soc. Japan,* **32,** 387–391 (1959).
11. K. Takiyama: Formation and Aging of Precipitates. (XII) Studies on Types of Crystal Growth of Barium Sulfate by Dissolution in Water., *Bull. Chem. Soc. Japan,* **32,** 442–445 (1959).

(c) **Vanadium Pentoxide**

12. E. Suito and K. Takiyama: Electron Microscopy and Diffraction Studies of Vanadium Pentoxide Sols., *Proc. Japan Academy,* **30,** 752–757 (1954).
13. E. Suito, K. Takiyama and N. Uyeda: Electron Micro-Diffraction Studies on the Alteration of Colloidal Crystalline Specimens., *Proc. 1st Regional Conference in Asia and Oceania, Tokyo,* 278–283 (1956).
14. K. Takiyama: Formation and Aging of Precipitates. (VI) Morphology of Crystals in Various Vanadium Pentoxide Sols by Electron Microscopy., *Bull. Chem. Soc. Japan,* **31,** 329–332 (1958).
15. K. Takiyama: Formation and Aging of Precipitates. (VII) Habit of Crystals in Vanadium Pentoxide Sols by Electron Microdiffraction Method., *Bull. Chem. Soc. Japan,* **31,** 555–557 (1958).

(d) **Colloidal Gold**

16. K. Takiyama: Formation and Aging of Precipitates. (VIII) Formation of Monodisperse Particles. (1) Gold Sol Particles by Sodium Citrate Method., *Bull. Chem. Soc. Japan,* **31,** 944–950 (1958).
17. E. Suito and N. Uyeda: Spiral Growth of Colloidal Gold and Moire Fringe., *Nature,* **185,** 453–454 (1960).
18. E. Suito and N. Uyeda: Spiral Growth of Lamellar Crystal of Colloidal Gold., *J. Electronmicroscopy,* **8,** 25–30 (1960).
19. E. Suito and N. Uyeda: Indented Growth Front of Single Micro-Crystal of Colloidal Gold., *Proc. Japan Acad.,* **37,** 388–392 (1961).
20. N. Uyeda: The Indented Perimeter as the Growth Front of the Lamellar Single Micro-Crystal of Colloidal Gold., *J. Electronmicroscopy,* **10,** 170–174 (1961).
21. E. Suito and N. Uyeda: Electron Microscopy and Diffraction Studies on the Growth and Structure of Laminar Single Crystals of Colloidal Gold., *Bull. Inst. Chem. Res., Kyoto Univ.,* **42,** 511–541 (1961).

(e) **Metal Phthalocyanines**

22. E. Suito, N. Uyeda and H. Shibanuma: The Transformation of Cu-phthalocyanine Crystal. Electron Microscope and X-ray Diffraction Study., *Bull. Inst. Chem. Res., Kyoto Univ.,* **32,** 83–85 (1954).
23. E. Suito and N. Uyeda: A Study of the Dimorphism and the Crystal Habit of Copper-Phthalocyanine by Electron Micro-Diffraction Method., *Proc. Japan Acad.,* **32,** 182–187 (1956).
24. N. Uyeda and E. Suito: A Study of Dimorphic Transformation of Copper Phthalocyanine in

Organic Suspension Medium by Cinematic Electron Diffraction Method., *J. Electronmicroscopy,* (Annual Ed.), **4,** 36-41 (1956).
25. E. Suito and N. Uyeda: Transformation and Growth Phenomena of Organic Micro-Crystals in Suspension State., *J. Electronkmicroscopy,* **5,** 13–14 (1956).*
26. E. Suito: Crystal Growth and Dimorphic Transformation of Organometallic Compounds..., *Fifth International Congerss for Electron Microscopy, Philadelphia,* **1,** H-2 (1962).
27. E. Suito and N. Uyeda: Transformation and Growth of Copper-Phthalocyanine Crystal in Organic Suspension., *Kolloid-Z.,* **193,** 97–111 (1963).
28. E. Suito and N. Uyeda: Transformation and Growth of Cu-Phthalocyanine in Organic Suspension., *J. Chem. Soc. Japan,* **86,** 969–977 (1965).*

(f) **Metal Oxinates**

29. M. Ishibashi, E. Suito and E. Sekido: Studies on the Precipitates of Metal Chelate Compounds in Analytical Chemistry. (I) Electronmicroscopic Observation of Various Metal Chelates Precipitates., *J. Chem. Soc. Japan,* **77,** 1836–1839 (1956).*
30. E. Suito and E. Sekido: The Dimorphism and the Crystal Habits of Copper-Oxinate Precipitates., *Proc. Japan Acad.,* **33,** 196–200 (1957).
31. M. Ishibashi, E. Suito and E. Sekido: Studies on the Precipitates of Metal Chelate Compounds in Analytical Chemistry. (II) Electronmicroscopic Observation of Copper-Oxinate Precipitates. (III) Analysis of Dimorphic Copper-Oxinate Precipitates. (IV) X-Ray Diffractometric Studies of Dimorphic Copper-Oxinate Precipitates., *J. Chem. Soc. Japan,* **78,** 1784–1795 (1957).*
32. E. Suito, M. Arakawa and T. Kobayashi: The Polymorphism of Copper-Oxinate Crystal., *Kolloid-Z.,* **213,** 135–143 (1966).
33. E. Suito, M. Arakawa and T. Kobayashi: The Phase Trasformation of Copper-Oxinate Crystals Observed by Electron Microscopy., *Kolloid-Z,.* **213,** 135–143 (1966).

Reviews

34. E. Suito: Formation and Crystal Shape of the Pigment Particles., *Pigment (Japan),* **5,** 355–361 (1961).*
35. E. Suito: Electron Microscopy of Crystals.-Crystal Structure and Crystal Growth., *Chemistry & Chem. Ind., (Tokyo),* **16,** 974–986 (1963).*
36. E. Suito: Formation of Fine Particles., *Colour Material (Japan),* **38,** 126–134 (1965).*

III. Structure and Crystal Growth of Vacuum-Evaporated Films

(a) **Inorganic Crystals**

1. E. Suito and M. Shiojiri: A Study of Epitaxial Growth of Vacuum-deposited Films of Cadmium Telluride., *J. Electronmicroscopy,* **12,** 134–137 (1963).
2. M. Shiojiri and E. Suito: The Structure of Vacuum-deposited Films of Cadmium Telluride., *Japanese J. Appl. Phys.,* **3,** 314–319 (1964).
3. E. Suito and M. Shiojiri: Electron Microscopy on the Crystallization Process of Titanium Dioxide Films., *Proc. Japan Acad.,* **41,** 455–460 (1965).
4. M. Shiojiri: Crystallization of Amorphous Titanium Dioxide Films Prepared by Vacuum-Evaporation., *J. Phys. Soc. Japan,* **21,** 335–345 (1966).
5. M. Shiojiri, H. Morikawa and E. Suito: Observations on the Crystallization Process of Amorphous Thin Films., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 467–468 (1966).
6. B.M. Siegel, N. Uyeda, J. Shin and J. Menadue: Electron Diffraction Studies at Intermediate Energies (50 kV) in an Ultra High Vacuum Camera: Kinetics of the Oxidation of Copper Deposits., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 537–538 (1966).
7. E. Suito, M. Shiojiri and H. Morikawa: Electron Microscopic Observation on Heat Oxidation of Vacuum-Deposited Aluminium Films., *Japanese J. Appl. Phys.,* **5,** 1197–1203 (1966).

(b) **Metal Phthalocyanines**

8. E. Suito, N. Uyeda and M. Ashida: Epitaxial Growth of Condensed Aromatic Polycyclic Compounds., *Nature,* **194,** 273–274 (1962).

9. N. Uyeda, M. Ashida and E. Suito: The Epitaxial Growth of Organic Semiconductor Materials on Mica., *Fifth International Congress for Electron Microscopy, Philadelphia,* **1,** GG-15 (1962).
10. N. Uyeda, M. Ashida and E. Suito: Orientation Overgrowth of Condensed Polycyclic Aromatic Compounds Vacuum-Evaporated onto Cleaved Face of Mica., *J. Appl. Phys.,* **36,** 1453–1460 (1965).
11. N. Uyeda and E. Suito: Some Behavior Structures of Leaf-Like Crystals of Copper-and Zinc-Phthalocyanines Vacuum-Deposited by Electron Bombardment., *Bull. Inst. Chem. Res., Kyoto Univ.,* **42,** 494–504 (1964).
12. E. Suito, N. Uyeda, M. Ashida and K. Yamamoto: Effect of Cleavage Steps of Muscovite on the Epitaxial Growth of Copper Phthalocyanine., *Proc. Japan Acad.,* **42,** 54–59 (1966).
13. M. Ashida, N. Uyeda and E. Suito: The Effect of Electron Irradiation on the Thermal Transformation of Copper-Phthalocyanine., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 447–448 (1966).
14. N. Uyeda, M. Ashida and E. Suito: The Effect of Molecular Interaction on the Epitaxial Nucleation of Organic Crystals., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 485–486 (1966).
15. M. Ashida, N. Uyeda and E. Suito: Unit Cell Metastable-form Constants of Various Phthalocyanines., *Bull. Chem. Soc. Japan,* **39,** 2616–2624 (1966).
16. M. Ashida: The Orientation Overgrowth of Metal-phthalocyanines on the Surface Crystals. (I) Vacuum-condensed Films on Muscovite., *Bull. Chem. Soc. Japan,* **39,** 2625–2631 (1966).
17. M. Ashida: The Orientation Overgrowth of Metal-phthalocyanines on the Surface of Single Crystals. (II) Vacuum-condensed Films of Copper-phthalocyanine on Alkali Halides., *Bull. Chem. Soc. Japan,* **39,** 2632–2638 (1966).

IV. Particle Size Determination

(a) Microscopic Method

1. E. Suito and M. Arakawa: Particle Size of Powder., *J. Electron-Microscopy* **5,** 56–57 (1956)*
2. E. Suito, N. Uyeda and M. Katsumi: The Measurement of the Size of the Colloidal Particle by the Ultracentrifugal Method and the Electron Microscopy., *Bull. Inst. Chen. Res., Kyoto Univ.,* **36,** 197–205 (1958).

(b) Sedimentation Method

3. E. Suito and M. Arakawa: Study of Particle Size Measurements. (I) An Automatic Sedimentation Balance and Some Results., *Bull. Inst. Chem. Res., Kyoto Univ.,* **18,** 43–44 (1949)*.
4. E. Suito and M. Arakawa: Sedimentometric Analysis for the Determination of the Distribution of Particle Size of Powder., *Bull. Inst. Chem. Res., Kyoto Univ.,* **7,** 7–17 (1950)*.
5. E. Suito, M. Arakawa and T. Arakawa: Measurement of the Particle Size Distribution of Portland Cements by the "Sedimentograph"., *Proc. Japan Cement Eng. Ass.,* **7,** 126 (1953)*.
6. E. Suito, M. Arakawa and N. Banba: Sedimentation Analysis of Powders. (III) Effect of Peptisers for Calcium Carbonate Suspension., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 368–369 (1953).
7. E. Suito, M. Arakawa and T. Arakawa: Sedimentation Analysis of Powders. (IV) Dispersion Agents for Cement Powder., *Bull. Inst. Chem. Res., Kyoto Univ.,* **31,** 369–370 (1953).
8. E. Suito, M. Arakawa and N. Banba: Effect of Peptizers on the Sedimentation Analysis of Particle Size., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **59,** 303–306 (1956)*.
9. M. Arakawa: A New Automatic Apparatus for the Particle Size Determination., *The Micromeritics, (Japan),* **5,** 14–17 (1960)*.
10. E. Suito, M. Arakawa, H. Mishima, S. Yano and N. Okamoto: A New Automatic Recording Instrument for the Determination of Particle Size Distribution by Sedimentation Method., *J. Soc. Materials Sci. Japan,* **13,** 825–827 (1964)*.
11. M. Arakawa and T. Kobayashi: Experimental Studies on Sedimentation Balance., *J. Res. Assoc. Powder Tech. (Japan),* **1,** 80–86 (1964).*

(c) Centrifugal Method

12. E. Suito, M. Arakawa, T. Masuda, S. Miwa and M. Sase: Auto-recording Centrifugal Instrument for Particle Size Determination., *Oyo Buturi,* **32,** 823–827 (1963).*

13. M. Arakawa: Auto-recording Centrifugal Instrument for Particle Size Determination., *J. Soc. Instrument & Control Eng. (Japan)*, **2,** 923–927 (1963).*

(d) **Adsorption Method**

14. E. Suito, M. Arakawa and T. Arakawa: Surface Area Mesaurement of Powders by Adsorption in Liquid Phase. (I) Calculation of Specific Surface Area of Calcium Carbonate Powders from the Adsorption of Stearic Acid. (II) Effect of Adsorbates and Solvents., *J. Chem. Soc. Japan,* **75,** 596–602 (1954)*.
15. E. Suito, M. Arakawa and T. Arakawa: Surface Area Measurement of Powders by Adsorption in Liquid Phase. (I) Calculation of Specific Surface Area of Calcium Carbonate Powders from the Adsorption of Stearic Acid. (II) Effect of Adsorbates and Solvents., *Bull. Inst. Chem. Res., Kyoto Univ.,* **33,** 1–13 (1955).
16. M. Arakawa: Surface Area Determination Apparatus by Gas Chromatography., *Res. Assoc. Powder Technology, (Japan),* **1,** 3–6 (1964)*.

(e) **Permeability Method**

17. M. Arakawa, T. Arakawa and E. Suito: The Measurement of Specific Area of Powders by Permeability Method., *Bull. Inst. Chem. Res., Kyoto Univ.,* **29,** 78, (1952).
18. E. Suito, M. Arakawa and M. Takahashi: New Apparatus for the Measurement of Specific Surface Area of Powder., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **59,** 307–310 (1956).*
19. M. Arakawa: Measurement of Surface Area of Powsders by Permeability Method., *Shimadzu-Laboratory (Kyoto),* (32)., **2,** 5–11 (1957).*
20. M. Arakawa and E. Suito: An Automatic Apparatus for the Particle Size Determination of Powder by Air-Permeability Method., *J. Japan Soc. Testing Materials,* **7,** 267–271 (1958).*
21. M. Arakawa and E. Suito: The Measurement of Particle Size of Ultrafine Powders by Air Permeability Method., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **63,** 556–559 (1960).*
22. M. Arakawa: A New Apparatus for the Mean Size Determination of Powder—"Permeasizer". *The Micromeritics, (Japan),* **7,** 17–20 (1961).*
23. M. Arakawa: Measurements of Surface Area by Permeability Method., *J. Soc. Instrument & Control Association, Japan,* **12,** 419–425 (1963).*

(f) **Method by Reaction Velocity**

24. E. Suito, N. Hirai and K. Taki: Determination of Particle Size Distribution by Kinetic Theory of Thermal Analysis. (I) Theory of Thermal Analysis on Determination of Particle Size Distribution. (II) Determination of Particle Size Distribution of Calcium-Carbonate by Disolving with Acid Solution., *J. Chem. Soc. Japan,* **72,** 713–717 (1951).*

Reviews

25. E. Suito: Apparatus for Particle Size Determination of Powders., *J. Japan Soc. for Test. Materials, (Japan),* **5,** 200–207 (1956).*
26. E. Suito and M. Arakawa: Comparison of the Particle Sizes of Powders Measured by Various Methods., *J. Electronmicroscopy,* **5,** 34–39 (1957).*
27. E. Suito: Determination of Particle Size., *Handbook of Experimental Chemistry* **2,** 433–484 (1957).*
28. M. Arakawa: Measurements of Particle Size of Powders., *Chemical Industry, (Tokyo),* 1–13 (1958).*
29. M. Arakawa: Measurement Method of the Pigment Particle Size., *Pigment, (Japan),* **2,** 68–71, 91–94, **3,** 111–112, 180–183 (1959).
30. M. Arakawa: Particle Size Measurement of Crushed Powders., *The Micromeritics, (Japan),* **3,** 4–7 (1959).*
31. M. Arakawa: Particle Size Measurement of Pigments , *Dyeing Ind. Japan,* **8,** 262–273 (1960).*
32. E. Suito: The Measurement of Particle Size in Very Fine Powders., *Review Chem. Eng. (Osaka),* **12,** 130–150 (1960).*
33. M. Arakawa: Surface Area Measurement of Powders by Adsorption in Liquid Phase., *Colloid and Surfactant, (Japan),* **1,** 223–230 (1960).*
34. E. Suito: Particle Characteristics and Particle Sizes of Powders., *The Society of Chemical Engineers, Japan, The Preprints of the* **25***th Anni. Congress.,* 187–195 (1961).

35. M. Arakawa: Fine Particle Measurement., *Colour Materials, (Japan)* **35,** 68–73 (1962).*
36. M. Arakawa: Advances in Powder Science.——Mainly about Technique of Measurements., *Colour Material, (Japan),* **36,** 57–62 (1963).*
37. E. Suito: Instruments for Particle Size Measurement., *Ind. & Industrial Products (Japan),* 127–132 (1963).*
38. E. Suito and M. Arakawa: Measurements of Specific Surface Area of Powders (I) Adsorption Method in Gas Phase (a) *Surface, (Japan),* **1,** No. 1, 79–82 (1963).*
39. E. Suito and M. Arakawa: Measurements of Specific Surface Area of Powders. (I) Adsorption Method in Gas Phase (b), *Surface (Japan),* **1,** No. 2, 84–87 (1963)*.
40. E. Suito and M. Arakawa: Measurements of Specific Surface Area of Powders. (II) Adsorption Method in Liquid Phase and Wetting Heat Method., *Surface, (Japan),* **1,** No. 3, 73–80 (1963).*
41. E. Suito and M. Arakawa: Measurements of Specific Surface Area of Powder. (III) Permeability Method., *Surface, (Japan),* **2,** No. 1, 78–83 (1963)*.
42. E. Suito: Measurement of Particle Size Distribution., *J. Soc. Instrument & Control Eng. (Japan),* **2,** 843–853 (1963)*.
43. E. Suito: Particle Size Measurement of Powders., *J. Japan Soc. Mechanical Eng.,* **67,** 1684–1693 (1964).*
44. E. Suito: Some Basic Problems of Powdery Medicine.—Morphology and Size of Powder., *Arch. Pract. Pharm. (Japan),* **25,** 175–181 (1965)*.

V. Physical Chemistry of Fine Powders

(a) Micromeritics

1. M. Arakawa, T. Okada and E. Suito: Effect of Particle Characteristics on the Static Properties of Powder., *J. Soc. Materials Sci. Japan,* **14,** 764–771 (1965)*.
2. M. Arakawa, T. Okada and E. Suito: Effect of Surface Characteristics of Particle on the Adhesion Property of Powders., *J. Soc. Materials Sci. Japan,* **15,** 151–155 (1966)*.
3. E. Suito, M. Arakawa, M. Sakata and Y. Natsuhara: Effects of Preparation of Solid Supports for Gas Chromatography on its Specific Surafce Area., *J. Soc. Materials Sci. Japan,* **15,** 178–183 (1966).*

Reviews

4. E. Suito: Characteristics of Powder., *Plant Engineering, (Japan),* **4,** 41–46 (1962)*.
5. E. Suito: On the Characteristic of Powders., *Plant Engineering (Japan),* **5,** 5–120 (1963)*.
6. M. Arakawa: Surface Chemistry of Powder., *Chemical Factory, (Japan),* **7,** 18–20 (1963)*.

(b) Organic Bentonite

7. E. Suito, M. Arakawa and S. Kondo: Infrared Studies of Some Complex between Montmorillonite and Octadecylamine or Steramide., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **66,** 1618–1621 (1963)*.
8. E. Suito, M. Arakawa, H. Hasegawa and S. Kondo: Structure of Organo-Bentonite., *Advances in Clay Science, (Japan),* **5,** 265–271 (1965)*.
9. E. Suito, M. Arakawa and T. Yoshida: Differential Thermal Analysis of Complexes of Octadecylammonium with Steramide in Bentonite., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **69,** 1125–1129 (1966)*.

VI. Dispersion State of Rubber-Filler System

(a) Electron Microscopic Investigations

1. E. Suito and M. Arakawa: Observation on the Dispersion State of Various Fillers in the Vulcanized Rubber by Electron Microscope., *Proc. Japan Academy,* **28,** 48–53 (1952).
2. E. Suito, M. Arakawa and H. Hasegawa: Electron-Microscopic Studies on Fillers for Rubber (I) Particle Size and Shape of Inorganic Fillers., *J. Soc. Rubber Ind. Japan,* **26,** 216–221 (1953)*.
3. E. Suito, M. Arakawa, H. Hasegawa and Y. Furuzawa: Electron-Microscopic Studies on Fillers for Rubber. (II) The State of Various Kinds of Fillers in Vulcanized Rubber., *J. Soc. Rubber Ind. Japan,* **26,** 453–458 (1953)*.
4. E. Suito, M. Arakawa, H. Hasegawa and Y. Furuzawa: Electron-Microscopic Studies on Fillers

for Rubber. (III) Effect of Milling for Dispersion of Fillers., *J. Soc. Rubber Ind. Japan,* **28,** 540–544 (1955)*.

5. E. Suito and M. Arakawa: Electron Microscopic Studies of Fillers in Rubber. (III) Effect of Milling on the Dispersion of Fillers., *Rubber Chem. and Technology,* **29,** 1003–1010 (1956).
6. E. Suito and M. Arakawa: An Electron Microscopic Study of the Dispersion State of Fillers in Vulcanized Rubber., *Proc. 1st Regional Conference in Asia and Oceania, (Tokyo)* 267–272 (1956).
7. E. Suito, M. Arakawa, H. Hasegawa and Y. Furuzawa: Electron-Microscopic Studies on Fillers for Rubber. (IV) State of Rubber-Filler System at the Elongation., *J. Soc. Rubber Ind. Japan,* **30,** 251–261 (1957)*.
8. E. Suito, and M. Arakawa: Electron Microscopy of Fillers in Rubber., *J. Soc. Rubber Ind. Japan,* **31,** 686–690 (1958)*.

Reviews

9. E. Suito: Rubber Fillers and its Reinforcing Action., *J. Soc. Rubber Ind. Japan,* **32,** 912–920 (1959)*.
10. E. Suito: Rubber Fillers and Electron Microscopy., *Polymer (Japan),* **11,** 55–59 (1961)*.
11. E. Suito: Reinforcement of Rubber with Fillers., *J. Soc. Rubber Ind. Japan,* **35,** 441–446 (1962)*.
12. E. Suito and M. Shiojiri: X-ray Analysis., *J. Soc. Rubber Ind. Japan,* **37,** 875–895 (1964)*.

(b) **Infrared Investigations**

13. E. Suito and M. Arakawa: Infrared Studies of Rubber-Filler System. (I) Infrared Spectra of Various Fillers., *J. Soc. Rubber Ind. Japan,* **34,** 884–894 (1961)*.
14. E. Suito and M. Arakawa: Infrared Studies of Rubber-Filler System. (II) Infrared Spectra of Rubber compounded with Filler., *J. Soc. Rubber Ind. Japan,* **34,** 894–900 (1961)*.
15. E. Suito and M. Arakawa: Infrared Studies of the Rubber-Filler System. (I) Inrfared Absorption Spectra of Inorganic Fillers., *Rubber Chem. Tech.,* **38,** 219–226 (1965).
16. E. Suito and M. Arakawa: Infrared Studies of the Rubber-Filler System. (II) Identification of Rubbers Compounded with Fillers by Infrared Absorption Spectra., *Rubber Chem. Tech.,* **38,** 227–282 (1965).
17. E. Suito and M. Arakawa: The Mechanism of Reinforcement with the Hard Clay., *J. Soc. Rubber Ind. Japan,* **36,** 704–709 (1963)*.
18. E. Suito and M. Arakawa: Infrared Studies of the Interaction between Rubber and Filler., *J. Chem. Soc. Japan, Ind. Chem. Sec.,* **66,** 1614–1617 (1963)*.
19. E. Suito and M. Arakawa: Mechanism of Reinforcement of Rubber with Hard Clay. Infrared Studies of Rubber-Fillers Systems. *Bull. Inst. Chem. Res. Kyoto Univ.,* **42,** 105–114 (1964).

VII. Colloidal Catalysis

1. E. Suito and H. Aida: Thermal Analysis on Hydrogenation of Fat. (I) Hydrogenation of Oleinic Acid and its Ester., *J. Chem. Soc. Japan, Ind. Chem. Soc.,* **54,** 765–768 (1951)*.
2. K. Tamura, K. Tarama and E. Suito: The Catalytic Decomposition of Hydrogen Peroxide by Gold Sol., *J. Chem. Soc. Japan,* **80,** 10–13 (1959)*.
3. K. Umeda, K. Tarama and E. Suito: Differential Thermal Analysis of Hydrogen Peroxide Decomposition by Various Evaporated Metal Films., *J. Chem. Soc. Japan,* **84,** 464–467 (1963)*.
4. K. Umeda, K. Tarama and E. Suito: Electric Properties and Catalytic Activities of Evaporated Metal Film., *J. Chem. Soc. Japan,* **84,** 553–557 (1963)*.
5. K. Umeda, N. Uyeda, K. Tarama and E. Suito: Structure and Catalytic Activity of Evaporated Metal Film., *J. Chem. Soc. Japan,* **84,** 557–560 (1963)*.

Reviews

6. K. Tamura: The Catalytic Decomposition of Hydrogen Peroxide in Aqueous Solutions., *Catalyst, (Japan),* **1,** 112–128 (1959)*.
7. E. Suito: Structure of Evaporated Films and its Catalytic Action., *Catalyst, (Japan),* **7,** 167–181 (1965)*.

VIII. Electron Microscopy

(a) Apparatus and Techniques

1. E. Suito and N. Uyeda: Studies on Micro-Crystals by Electron Microdiffraction (Preliminary Report), *Bull. Inst. Chem. Res. Kyoto Univ.*, **29,** 75 (1952).
2. E. Suito and N. Uyeda: Studies on the Shadow Microscope as an Attachement of Electron Microscope., *Bull. Inst. Chem, Res. Kyoto Univ.*, **29,** 76 (1952).
3. E. Suito and N. Uyeda: On the Characteristic Properties of the Three-Stage Electron Microscope SM-C3 as an Electron Diffraction Camera., *Bull. Inst. Chem. Res., Kyoto Univ.*, **32,** 85–87 (1954).
4. E. Suito and N. Uyeda: On the Diffraction Patterns Corresponding to the Specimens at Various Glancing Angles to the Electron Beam in a Three Stage Electron Microscope., *J. Electron-Microscopy* **4,** 239–245 (1955)*.
5. E. Suito, N. Uyeda and K. Takiyama: A Specimen Preparation Technique for the Crystal Habit Analysis of Fibrous Crystals., *J. Electronmicroscopy,* **5,** (Annual Edition) 14–18 (1957).
6. N. Uyeda and E. Suito: Electron Micro-Diffraction of various Metal Phthalocyanine as the Sample of Crystal Lattice Image., *J. Electronmicroscopy,* **6,** 31–33 (1958)*.
7. E. Suito, N. Uyeda, H. Watanabe and T. Komoda: Lattice Image of Twin Structure observed directly by Electron Microscope in a Crystal of Copper Phthalocyanine., *Nature,* **181,** 332–333 (1958).
8. N. Uyeda: The Crystal Structure Analysis by the Subsidiary Maxma of the Electron Diffraction Pattern., *Bull. Inst. Chem. Res., Kyoto Univ.*, **35,** 105–122 (1957).
9. E. Suito, N. Uyeda and Y. Matsumura: Micro-Focus X-ray Diffraction Unit as an Attachment to an Ordinary Electron Microscope., *J. Appl. Phys. Japan,* **28,** 561–568 (1959)*.
10. E. Suito and N. Uyeda: Electron Microscopic and Diffraction Studies of Superimposed Lamellar Crystals., *Fourth International Conference on Electron Microscopy, Berlin,* **I,** 355–359 (1958).
11. E. Suito and N. Uyeda: The Anomalous Diffraction Contrast on (111)-Face of Lamellar Single Micro-Crystal of Colloidal Gold., *J. Phys. Soc. Japan,* **17,** Supplement B-II, 217–220 (1962).

(b) High Voltage Electron Microscope

12. E. Suito, K. Kobayashi, S. Shimadzu and M. Iwanaga: A New 350 KV Universal Electron Microscope., *J. Electron Microscopy,* **7,** 102–105 (1959)*.
13. E. Suito, N. Uyeda, M. Arakawa, K. Kobayashi, A. Nakamura, H. Hashimoto and M. Kurokawa: Electron Diffraction Study with the 350 KV Electron Microscope., *J. Electron Microscopy,* **7,** 105–107 (1959)*.
14. K. Kobayashi, E. Suito and S. Shimadzu: A New High Voltage (350 KV) Universal Electron Microscope and its Applications., *Fourth International Conference onElectron Microscopy, Berlin,* **I,** 165–169 (1958).
15. H. Hashimoto, K. Tanaka, K. Kobayashi, E. Suito, S. Shimadzu and M. Iwanaga: Absorption and Diffraction Effects of Electron Waves Observed in 300 KV Electron Microscopic Images., *J. Phys. Soc. Japan,* **17,** Supplement B-II, 170–174 (1962).
16. K. Kobayashi, H. Hashimoto, E. Suito, S. Shimadzu and M. Iwanaga: Construction of 300 KV Electron Microscope and its Electronmicroscopy., *Japanese J. Appl. Phys.*, **2,** 47–57 (1963).
17. H. Hashimoto, K. Tanaka, K. Kobayashi, E. Suito, S. Shimadzu and M. Iwanaga: Extinction Distance and Transmissive Power of Electron Waves in Crystals., *Memoirs of the Faculty of Ind. Art., Kyoto Tech. Univ., Sci. Tech.*, **13,** 1–17 (1964).
18. E. Suito: High Voltage Electron Microscopy in Japan., *Proc. Second Reg. Conf. Electron Microscopy in Far East and Oceania, Culcutta,* 9–12 (1965).
19. K. Kobayashi, E. Suito, S. Shimadzu and M. Iwanaga: Construction of 300 KV Electron Microscope., *Bull. Inst. Chem. Res., Kyoto Univ.*, **42,** 425–438 (1964).
20. K. Kobayashi, E. Suito, S. Shimadzu, T. Hori and M. Iwanaga: Construction of 500 KV Electron Microscope., *Bull. Inst. Chem. Res., Kyoto Univ.*, **42,** 439–456 (1964).
21. H. Hashimoto, K. Tanaka, K. Kobayashi and E. Suito: Electron Microscopic Images of

Crystals Observed with 300 KV Electron Microscope., *Bull. Inst. Chem. Res., Kyoto Univ.*, **42,** 457–472 (1964).

22. S. Shimadzu, M. Iwanaga, K. Kobayashi, E. Suito, T. Taoka and H. Fujita: Instrument Features of 500 KV Electron Microscopes., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 101–102 (1966).
23. K. Kobayashi, E. Suito, N. Uyeda, T. Hori, N. Iwasa and M. Ohara: Recent Achievements in High Voltage Electron Microscopy., *Sixth International Congress for Electron Microscopy, Kyoto,* **1,** 111–112 (1966).

Reviews

24. E. Suito and N. Uyeda: Electron Micro-Diffraction Method., *Kagaku-no-Ryoiki, (Japan)*, **8,** 147–156 (1954).*
25. E. Suito: Application of Electron-Microscope to Chemistry., *Kagaku-no-Ryoiki, (Japan)*, **10,** 359–366 (1956).*
26. E. Suito: Studies of Micro-Crystals by the Electron Micro-Diffraction Method., *J. Electron-Microscopy,* **5,** 173–183 (1957).*
27. E. Suito: Direct Observation of Crystal Lattice by Electron Microscope., *Chemistry, (Kyoto)*, **12,** 410–417 (1957).*
28. E. Suito and N. Uyeda: Crystal and Electron Microscopy., *Chemistry, (Kyoto)*, **13,** 88–96 (1958).*
29. E. Suito: Electron Microscopy of Clay Minerals., *Advances in Clay Science (Japan)*, **1,** 166–180 (1959).*
30. N. Uyeda: Electron Microdiffraction Study of Clay Minerals., *Advances in Clay Science (Japan)*, **1,** 181–193 (1959).*
31. E. Suito: Application of Electron Microscope in the Chemical Industry., *Chem. Ind. (Tokyo)*, 1–6 (1960).*
32. E. Suito and M. Arakawa: Electron Microscopy and Paint Technology., *J. Japan Soc. Colour Material,* **34,** 124–132 (1961).*
33. M. Arakawa: Electron Microscopic Technique for Powder Research., *Pigment (Japan)*, **5,** 530–534 (1961).*
34. E. Suito: Application of Electron Microscopy in Ceramic Industry., *J. Ceram. Assoc. Japan,* **69,** 465–473 (1961).*

IX. Miscellaneous Publications

1. E. Suito, K. Takiyama and H. Shibanuma: On the Relation between the Color and the Quantity of Iron in Paper Clay., *Bull. Inst. Chem. Res., Kyoto Univ.*, **31,** 49–51 (1953).
2. K. Takiyama and E. Suito: Qualitative Analysis by means of Anion Ecxhange Resin., *Japan Analyst,* **4,** 8–11 (1955).
3. K. Takiyama: Simple Instrument for Potentiometry and Conductometry., *Japan Analyst,* **5,** 574–575 (1956).*
4. J. Matsuda and E. Suito: Studies of the Crystallization of Lithium Silicate Glasses., *J. Chem. Soc. Japan, Ind. Chem. Sec.*, **67,** 884–886 (1964).*

Reviews

6. E. Suito: Inspection of Tour in Europe. —On the Filler of Rubber— *J. Soc. Rubber Industry Japan,* **32,** 187–194 (1959).*
7. E. Suito: Miscellaneous Impressions on the Pigments in Europe., *Pigment (Japan)*, **3,** 98–99 (1959).*
8. E. Suito: Miscellaneous Impression on the Electron Microscopy in Europe., *Chem. and Chem. Industry, (Tokyo)*, **12,** 362–365 (1959).*
9. E. Suito: Impressions on the International Conference of Electron Microscopy at Berlin., *Polymer (Japan)*, **8,** 73–76 (1959).*
10. E. Suito: Particle Size Measurement of Powder in Europe., *The Micromeritics (Japan)*, **3,** 2–3 (1959).*

11. E. Suito: On the Visit to Prof. Schwab in München University., *Catalyst (Japan)*, **1**, 167–170 (1959).*
12. E. Suito: Impressions on the 2nd Regional Conference for Electron Microscopy in Asia and Oceania., *J. Electron Microscopy*, **13**, 241–245 (1964).*

X. Books

1. E. SUITO: Application of Electron Microscopy in Colloid Science, in K. Sasagawa's "*Electron Microscope*", 202–223, Honda Pub. Co., Kyoto (1951).*
2. E. SUITO, N. UYEDA: Thermochemistry, Chemical Kinetics, in R. Goto's "*Experimental Methods in Physical Chemistry*", 16–32, 144–161, Kyoritsu Pub. Co., Tokyo (1952).*
3. E. SUITO: Reaction in Liquid Phase, in N. Sasaki's "*Chemical Kinetics*", 189–282, Kyoritsu Pub. Co., Tokyo (1953).*
4. E. SUITO: "Colloid and Powder, Atlas of Electron Micrographs", Honda Pub., Kyoto (1954).
5. E. SUITO, N. UYEDA: Electron Micro-diffraction Method, in "*Solid Physical Chemistry*" in the Series of Handbook on Experimental Chemistry, 299–345, Maruzen Co. Ltd., (1956).*
6. E. SUITO: Determination of Particle Size, in "*Fundamental Technique*" in the series of Handbook on Experimental Chemistry, 433–484, Maruzen Co. Ltd., (1957).*
7. E. SUITO: Applications of Electron Microscopy to Colloid Science, in Higashi's "*Recent Applied Electron Microscopy*", 172–197, Nagai Pub. Co., (1957).*
8. E. SUITO, K. TAKIYAMA, M. ARAKAWA: Colloid and Powder, in "*Electron Microscopy, Theory and Practice "III" Application to Science and Industry*", 127–180, Maruzen Co. Ltd., (1960).*
9. N. UYEDA: X-ray Spectrochemical Analysis, in "*The Instrumental Method for Analytical Chemistry*", 515–557 (1960).*
10. E. SUITO: "The World through the Electron Microscope, Chemistry. (I)," Japan Electron Optics Laboratory Co. Ltd., (1960).
11. E. SUITO: Fillers and Pigments for Paper Industry—Shape and Particle Size—, in "*Paper and Pulp—Materials and Technology*", 440–461, (1962).*
12. K. KUBO, E. SUITO, Y. NAKAGAWA and S. HAYAKAWA: "Powder—Theory and Application—", Maruzen Co. Ltd., (1962).*
13. E. SUITO: "The World through the Electron Microscope, Chemistry. (II)", Japan Electron Optics Laboratory Co. Ltd., (1963).
14. E. SUITO: "The World through the Electron Microscope, Chemistry. (III)", Japan Electron Optics Laboratory Co. Ltd., (1966).*
15. E. SUITO, K. UMEDA: "Catalytic Action by Colloids", in "*Technology of Catalysis*", **6**, 272–296, Chijin Shokan, Tokyo (1966).*
16. E. SUITO, S. TANEYA: "Theory on Powdery Food", in J. Nikuni and T. Hata's "*Handbook on Foundamental Food Chemistry*", 365–406, Asakura Pub. Co. Tokyo (1966).*